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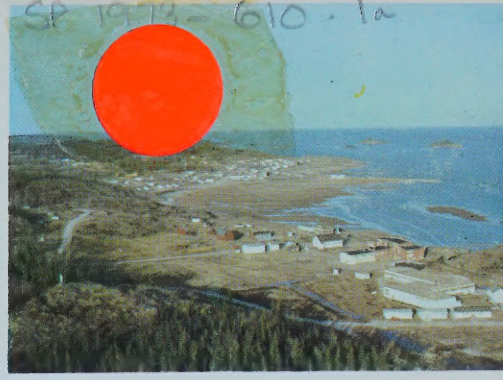
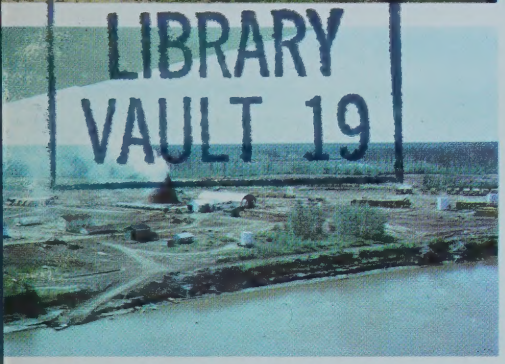

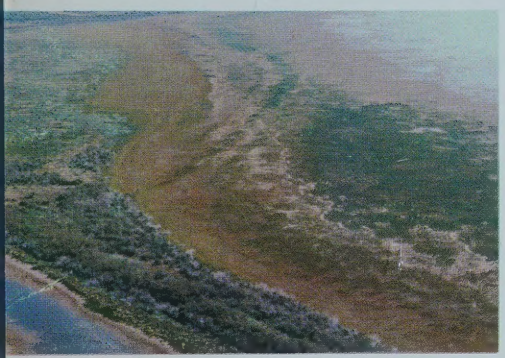

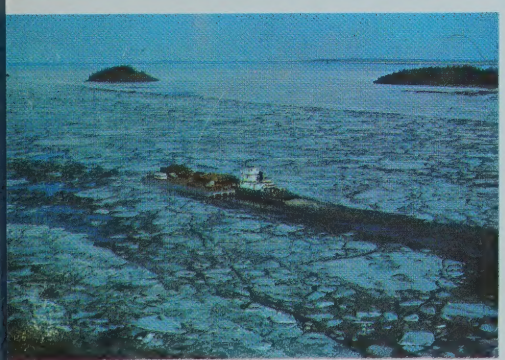

THE PEACE – ATHABASCA DELTA
A CHOICE OF WATER MANAGEMENT ALTERNATIVES

Alberta
ENVIRONMENT

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THE PEACE-ATHABASCA DELTA

A CHOICE OF

WATER MANAGEMENT ALTERNATIVES

An examination of the effects on resources and people near Fort Chipewyan, Alberta, of remedial measures proposed to alleviate adverse conditions on the Peace-Athabasca Delta caused by impoundment of the Peace River by Bennett Dam in British Columbia.

by

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ALBERTA DEPARTMENT OF THE ENVIRONMENT

Approved and published
under authority of

THE HONOURABLE W.J. YURKO, P. Eng.
MINISTER OF THE ENVIRONMENT

This document has been prepared to facilitate discussion at public hearings by the Environment Conservation Authority on water management proposals made to the Governments of Canada, Alberta and Saskatchewan by the Peace-Athabasca Delta Project Group.

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INTRODUCTION

Two highly significant facts should be recognized by anyone interested in the Peace-Athabasca Delta - it is one of the world's great freshwater delta marshland complexes, and it has been home for a large number of Canadians for almost 200 years. It is no accident that Fort Chipewyan has provided a focus for entry to the Canadian Arctic, both as a major southern terminal of the Mackenzie River waterway, and as a center of fur trading in its own right. Thus, the early traders and travellers proceeding "from Canada by land" as Mackenzie expressed the culmination of his trip to Bella Coola on the west coast in 1793, as well as the original Indian residents of the upper Mackenzie system, were oriented to an important transportation and trading center, surrounded by a rich deltaic environment in an arc from northwest to southeast, and fronting on the Canadian Shield to the northeast.

Present patterns of human habitation and social structure of Fort Chipewyan have roots far deeper than most Alberta communities. Other than Indians, a large proportion of Alberta citizens have few Canadian antecedents over 100 years in the past. When Government or its agents cause changes in an environment such as the Peace-Athabasca Delta (as the British Columbia Hydro and Power Authority caused alterations in water levels by damming the Peace River) subsequent reactions can be expected by those affected by such man-induced changes. It would be a mistake to suggest that wide changes had not occurred in water levels in the Delta in the past; evidence is strong that they had. However, the record indicates that natural variations, whether toward higher or lower water levels, did not establish long term trends and reversed themselves within a few years. The impoundment of the Peace River, however, changed the fundamental relationship between Peace River flows and regulation of Lake Athabasca and the Delta marshlands to such a degree that recognition had to be given to the fact that drying of the Delta would be progressive, with continued regulation of Peace River flow in British Columbia, and that deleterious and irreversible changes would occur to ecological conditions on the Delta,

without provision of remedial measures. Urgency was imparted to the situation on the Delta for several reasons. About two thirds of the affected marshland lies in Canada's largest National Park; the Delta complex is a staging area for more than 1,000,000 waterfowl from four continental flyways; navigation, was impaired on river channels in or adjacent to the Delta, because of low water. No factor, however, compared in importance or urgency with the fact that 1500 residents of the area were threatened with widespread and permanent damage to resources upon which they depended for sustenance, and the likelihood of community disruption because of the suddeness and magnitude of change in their way of living.

This report is not intended to provide only a summary of events concerning recent happenings on the Peace-Athabasca Delta, nor is it intended to recapitulate the reports and recommendations of the Peace-Athabasca Delta Project Group. Rather the position is taken that the research carried out by the Peace-Athabasca Delta Project Group provides at this time a reasonable basis for anticipating the future course of events, if the recommendations of the Delta Project Group are followed by the Governments involved.

The Minister of the Environment for Alberta has directed that public hearings be held before any major environmental management proposal of any kind is implemented in the Province. The scope of remedial measures proposed for water level improvement on the Delta affects 3000 square miles of Alberta and Federal land and a large number of Canadian citizens resident in the area. It is hoped that this report will provide a basis for public discussion which can lead to the maximum level of public benefits for all residents of the area, for other Albertans, and for Canadians everywhere who have an interest in the problem, because much of the affected area is in Wood Buffalo National Park.

1. THE PEACE-ATHABASCA DELTA

1.1 Geographic Location

For this report, an area somewhat larger than the actual Peace-Athabasca Delta is considered. The Delta itself is a little less than 1500 square miles, but its influence extends more nearly over 3000 square miles of upland, marshland and water-covered areas. As well, the lands which may infrequently be inundated, but which bear close relation to the Delta, its resources and the local residents, cannot easily be separated from any discussion of the Delta proper. A very considerable body of information has been assembled on the Peace-Athabasca Delta and the surrounding area, especially since 1970, when the attention of the public first was focused on this little known region (1).

Figure 1 shows an outline of the Province of Alberta, with the area to be discussed indicated as a shaded portion lying to the west of Lake Athabasca, about 350 miles northeast of Edmonton. As indicated earlier, the Delta is a natural terminus to travel routes from the south, east, or north. Stable, mature land surfaces in the active, outer edges of the Delta are not extensive, and most permanent habitation is located at Fort Chipewyan, on the non-deltaic Canadian Shield east of the delta and lying on the north shore of Lake Athabasca. Figure 2 shows the region immediately adjacent to Fort Chipewyan in more detail.

Access to Fort Chipewyan and the adjacent area is by air, by boat north from Fort McMurray or Saskatchewan to the east, during the ice free period, and by winter road from Fort Smith in the Northwest Territory. Geographical isolation has required that great reliance be placed on shipment of supplies by barge or air, or by truck haul in the winter. As well, outgoing products (fish, fur, lumber) are subject to the same transportation limitations as incoming supplies. Similarly, travel by local residents is by boat, air, snowmobile, dog team, or on foot, depending on circumstances and season. To a very significant degree, the geographic location and isolation of the Delta and its human inhabitants has shaped the destiny of the community of Fort Chipewyan, and determined the life style of its people.

FIGURE 1: MAP OF THE PROVINCE OF ALBERTA, SHOWING THE PEACE-ATHABASCA DELTA STUDY AREA AS SHADED PORTION IN EXTREME NORTH EAST

FIGURE 2
PEACE - ATHABASCA DELTA

SCALE: 1 inch = 10 miles

1.2 Historical Background

The community of Fort Chipewyan has existed for about 200 years. Residents have adopted a life style strongly oriented to their environment and the occupations of trapping, hunting and fishing. Thus, the relationship between human ecology and resources has become established not only as a means of survival in an often harsh environment, but also has become deeply ingrained as an historical social tradition in the lives of most members of the community.

Mentioned earlier was the evidence for wide variability in the Delta marshland environment in the past. Historical evidence indicates also (2) that a gradual shift has occurred from the function of Fort Chipewyan as a "staging area" for trappers and fur traders to that of a permanent, residential community at present. Very few permanent residences exist now outside of Fort Chipewyan on the upland, wooded Canadian Shield, on the south shore of Lake Athabasca, or along the river and delta channels. It is not possible from available records to determine accurately the past population density or distribution, or how or why these may have changed. Changes have occurred in the fur trade and in Government activities, which could have affected residential patterns. More recently establishment of schools, as well as increased social assistance probably have increased the numbers of permanent residents in Fort Chipewyan.

Activities of Delta residents predictably follow and are strongly influenced by the changing seasons. According to Weutherick (2) traditional patterns of community behaviour by 1900 may have begun a significant shift toward that of today, but old traditions die hard, and preparation of winter gear, such as clothing, snowshoes, sleds and the like, still has a significant place in the lives of many individuals in the Delta area. Winter is of course, coincident with the height of trapping activities. The community in the past has depended on muskrat as the dominant furbearer, and until comparatively recent times (3) the winter life of Fort Chipewyan was oriented almost entirely to the twin occupations of hunting and trapping, with some fishing with nets set under the ice, in order to obtain sufficient food. In the past also, considerable effort was expended in fishing

for dog food, although this activity has decreased with the use of alternate methods of transportation, other than dog sleds. Spring and fall are difficult travel periods in the Delta area. Overflooding of surface ice often occurs in late winter or spring, and late fall or early winter ice thickness often is hazardous for travel. Net fishing traditionally has been carried out as required during any season, with fish being one of the important food items, both for humans and their dogs. Traditionally also, summer is used extensively for boat travel, and camping by families throughout the Delta is an activity still widely practised.

The foregoing brief summary of community behaviour patterns is intended only to indicate that the majority of residents of the Delta area still may be strongly influenced by old and stable traditions of resource use. Dependence by the residents on the Delta resources will be discussed later. Some younger residents have discarded completely the old dependencies and traditional occupations, and now have permanent jobs with Government agencies, airline or water transportation companies, or may be employed in lumbering or similar occupations. By and large, however, the community is still strongly oriented to the past, although signs of transition are evident. The importance of transition to possible new involvements, particularly with respect to the proposed remedial measures for water level improvement, will be discussed in a later section.

2. PEACE RIVER REGULATION IN BRITISH COLUMBIA

For several thousand years the Peace River, fed by its two major basin tributaries (Parsnip and Finlay), has carried downstream uncounted millions of tons of sediments each season. These sediments have built the Peace, Slave and Mackenzie deltas on which have become established plants and animals uniquely adapted to deltaic conditions. River channels and deltas are born, change, grow and die through the complex interactions of natural processes. These changes generally are slow, and communities of plants and animals and man usually can adapt to them. Regulation of the Peace River in British Columbia for hydroelectric power production

produced changes of great magnitude, with sudden results. How these changes took place, and how the public and Government responded to them is briefly outlined below.

2.1 Relationship of Peace River Flows to Water Levels in Lake Athabasca

Measurements have been made of flows on the Peace River for many years (3). As well (4), the relationship between Peace River flows and water levels in Lake Athabasca has been studied. High spring flows in the Peace River provided a hydraulic barrier against Lake Athabasca outflows. In addition, high flows on the Peace River, as well as impoundments on the Peace River caused by ice jams, caused the Peace temporarily to reverse its normal northward flow and to spill into the Delta and Lake Athabasca to the south. Thus, the water levels on the Peace River largely controlled the level of Lake Athabasca by impounding several feet of water on the lake each year. The impounded water flowed out during the late summer, fall and winter, with the result that water levels in the lake fluctuated from a high in mid-summer, to a low in early spring.

Regulation of the Peace River in British Columbia reduced the spring peak water levels in the Peace by several feet. As a result, Lake Athabasca peak water levels were also reduced by a substantial amount. Outward flows through the channels from Lake Athabasca increased with lower water in the Peace River, because their discharge capacity from Lake Athabasca is partly dependent on Peace River water levels. In summary, control of Peace River water in British Columbia had the direct effect of lowering the peak levels of the Peace River and Lake Athabasca.

2.1.1 Effects on Water Levels in the Delta Marshlands

During the late summer of 1968, after closure of the dam on the Peace River in British Columbia in December, 1967, some of the Delta lakes almost disappeared. The runoff in 1968 was lower than average, and coupled with virtually a total cessation of flow on the Peace River, effects were immediately felt on the Delta marshlands. It is known that water levels in Lake Athabasca control to a large degree the water levels in the shallow

marshes of the Delta, and during the period 1968-1970 the peak levels in Lake Athabasca were about five feet below the long term average highs.

2.1.2 Public Recognition of the Delta Problem

Following the drastic reduction in water levels in the Delta, observations were made of the sequence of events occurring on the Delta marshes. It was known by the spring of 1970 that many Delta lakes had frozen to the bottom in the winters of 1968-69 and 1969-70. By mid-summer of 1970 it was also suspected that valuable habitat was unavailable to important fish and furbearing species.

Public attention was focused on the Delta water problem by publication of "Death of a Delta" in Edmonton by concerned scientists and others from the Government of Alberta, Government of Canada and the University of Alberta. By September, 1970, public knowledge of the Delta was widespread, and by early 1971 a decision had been made to hold a symposium on the Delta problem at the University of Alberta in Edmonton. A large amount of information was recorded and published in the proceedings of the symposium (5).

2.1.3. Action by Governments

Concurrent with preparations for public discussion, the responsible Ministers for Alberta, Canada and Saskatchewan agreed to establish a Delta Project Group, to study the problem and make recommendations to the three governments. By January 1971 the project study was under way. The initial report of the Peace-Athabasca Delta Project Group was published in 1971 (6); a summary report was published in 1972 (4); final recommendations were made by the Delta Project Group in 1973 (7).

In May, 1973 the Minister of the Environment for Alberta, the Honourable W.J. Yurko announced that the Environment Conservation Authority had been requested to hold public hearings on recommendations made by the Peace-Athabasca Delta Project Group for restoration of water levels on the Peace-Athabasca Delta. The announcement by the Minister is in keeping with

policy stated by the Government of Alberta that no large-scale water or other environmental management project will be initiated in the Province without public hearings, in order that all Alberta citizens be provided with the opportunity to participate in the decisions affecting their environment.

2.2 Peace-Athabasca Delta Studies

The public hearings by the Environment Conservation Authority are the culmination of a long series of events, commencing in December 1967, when the B.C. Hydro and Power Authority closed the dam on the Peace River in British Columbia. Very detailed and extensive studies have been carried out, and it was in April, 1973 that the Delta Project office was closed, with submission of the final recommendations on restorative measures for the Delta marshlands. During the more than two years of study, a wide involvement of more than 30 agencies was achieved. The reports of the studies mentioned earlier, all show strong indications of concern for the people of Fort Chipewyan and their dependence on Delta resources. This report has the same kind of orientation, and as a consequence, less attention is devoted to the technical aspects of Delta ecology and hydrology, and considerably more to the relationship of the people to the resources of the area.

2.3 Recommendations of the Peace-Athabasca Delta Project Group

As mentioned earlier, three reports were produced by the Peace-Athabasca Delta Project Group. Each of these reports contained recommendations. The final report to the three Governments also has attached to it voluminous appendices, wherein are contained the technical data upon which the Delta Project Group based its final recommendations. It is necessary to clearly outline the major recommendations for remedial works (and the expected consequences) in some detail, because it is these which can have the most far-reaching effects on people of the Delta area. As well, mention should be made of possible downstream effects if the major recommendation for water control in Lake Athabasca is implemented.

2.3.1 Alternatives

There are at least three alternatives available for management of water levels in Lake Athabasca and the Delta marshlands:

(a) The situation could be left as at present, with a trend toward progressive drying out of the Peace-Athabasca Delta.

(b) The Delta water levels could be stabilized permanently, by erection of a regulatory dam or dams on the outlet(s).

(c) Partial control of outflowing water could be achieved by construction of a partial blockage on the major outlet channel, Rivière des Rochers.

No one, in a few months' study could predict with certainty the quantitative changes which might take place with any of the choices listed above. However, events following choices (a) or (b) are predictable in the broad sense. If the Delta continued to dry out, the marshlands would quickly be covered initially by deciduous trees, finally to be replaced by conifers. Eventually (100-200 years), a boreal forest cover would predominate over most of the present Delta marshland complex. If water levels were increased and stabilized by regulating the water regime, both external to and within the Delta, primary productivity would be sharply reduced (8). The large, shallow lake resulting from such an action would not provide the kind of habitat which in the past has resulted in the production of large numbers of muskrats, suitable spawning conditions for walleye, goldeye and pike, sedge meadows for bison, and optimum conditions, both in spring and in autumn, for staging waterfowl. Alternative (c) appears to be the only reasonable course of action to ensure the preservation of delta marshland productivity, and to prevent further changes of the nature already recorded by investigators (9).

The Peace-Athabasca Delta Project Group, in its final report (7) has made the recommendation that a submerged rock-fill weir be constructed at the Little Rapids site on the Rivière des Rochers, the main outlet channel from Lake Athabasca to the Slave River. According to the report, and the appendices attached to it, the submerged weir on the Rivière des

Rochers will provide enough check on outflow that Lake Athabasca will rise each spring during accelerated runoff to a level of about 689 feet above sea level (about the average peak level before regulation of the Peace River). Such a level is suggested in order that the Delta marshlands be flooded to approximately the same extent as that which existed in the past. The report anticipates also that Lake Athabasca will fall to a level of about 685 feet above sea level each winter. In general, the amplitude of fluctuation of water levels would be slightly less than before the Peace River dam was built. Shoreline zones would likely be slightly more stable. Biological productivity is estimated to be approximately the same as that which existed before the Peace River impoundment imposed a new and deleterious water level regime on the Peace-Athabasca Delta.

Several alternatives were considered for regulation of water levels which would approximate pre-impoundment conditions on the Delta marshlands. These varied from temporary ice dams, regulated flows by gated structures, partial constrictions of outflow channels, and regulation of the main flow in the Slave River itself. Details of construction and assessments of comparative advantages of the several alternatives are contained in the Technical Report and Appendices mentioned earlier (7). As well as the major control on the Rivière des Rochers, the recommendation was made by the Peace-Athabasca Delta Project Group that the dam on the Chenal des Quatre Fourches (already constructed) be removed, in order not to impair water quality in the basins whose water levels it affects.

2.3.2 Long-term Projections for Water Levels

Predictability of the water regime on the Peace-Athabasca Delta is the major key to estimating resource values. It was indicated earlier that historically the people of Fort Chipewyan were strongly oriented to biological resources of the area. These resources depend for their existence on the unique conditions to be found in the complex of basins, levels and channels which make up the Delta.

Under the regime envisaged in the report and recommendations of the Peace-Athabasca Delta Project Group, it is estimated that the variable, but

predictable levels recorded in the past can be approximated for the foreseeable future, if the Rivière des Rochers weir is constructed. It is to be expected that there will be relatively drier and wetter years in the future, as there have been in the past. Consequently, both maximum and minimum water levels on the Delta will likely fluctuate outside the range of 685-689 feet above sea level. Annual flows on the Fond-du-Lac River in Saskatchewan (7 million acre feet) and the Athabasca River in Alberta (25 million acre feet) jointly make up the significant portion of the annual throughput of Lake Athabasca. The combined capacity of the two systems may vary substantially, which accounts for the predicted variability in water levels on the Delta marshlands. It is important to record that any significant storage projects which might be built on the Fond-du-Lac or Athabasca systems would have immediate impact on Lake Athabasca water levels and the water regime of the Delta, by lowering the spring and summer inflows to Lake Athabasca. It could be expected that initiation of any such storage of a significant nature on the major tributaries to Lake Athabasca would result in essentially the same kind of impact on the Delta as that caused by regulation of the Peace River in British Columbia.

2.3.3 Downstream Effects

Studies of the downstream effects of Peace River regulation have been concentrated largely in the region of the Delta. Below the confluence of the Peace, Slave and Rivière des Rochers, unquantified effects will result from regulation of levels in Lake Athabasca. At present, the outflows from Lake Athabasca are greatly accelerated by low spring water levels in the Peace River; the throughput of water from Lake Athabasca in effect compensates in part for storage achieved on the Peace River in British Columbia. It properly cannot be said, therefore, that storage of water behind the Rivière des Rochers weir affects the lower Slave and Mackenzie, but rather, such storage makes more apparent the true impact downstream of storage on the Peace River in British Columbia. Thus, any measures considered necessary to returning Lake Athabasca and the Delta to a more "natural" state, will result from the operation of the hydrodam on the Peace River. Further, any downstream effects caused by remedial

measures should be assigned to the operation of the dam in British Columbia, and not to implementation of restorative programs in Alberta.

2.3.4 Environmental Impacts

It has been stated earlier (page 9) that of the options available, the only reasonable course appears to lie in effecting at least partial control of waters outflowing from Lake Athabasca and the Delta, to ensure preservation of deltaic marshland productivity. As also indicated earlier, such a course would return the Delta to a condition where inflowing water through the Fond-du-Lac and Athabasca systems would provide a water regime on the Delta which would be subject to the vagaries of nature. Such a water regime would be much more akin to the "natural" state which existed prior to construction of the dam on the Peace River in British Columbia than that which exists at present.

Thus far, this report has dealt with the identification of the Peace-Athabasca Delta as a unique geographical entity, with a highly important social and historical background, covering nearly two centuries in time. In addition, the relationship of Peace River flows and their relation to Delta water levels and resources has been examined, as well as the restorative measures recommended by the inter-governmental Peace-Athabasca Delta Project Group.

Focus should now be directed to the environmental consequences of implementing the basic recommendations in the final report of the Peace-Athabasca Delta Project Group. In providing such an analysis, the assumption is made that restorative measures will be effected in the near future. A second assumption is made that the method of achieving full restoration of a "natural" water regime on the Delta is less important than is the likelihood of maximizing Delta productivity for the use of Delta residents.

During the past few years, several techniques have been developed for depicting the complex interrelationships of an activity by man and one or more environmental systems affected by that activity. One such technique involves the construction of an "environmental impact matrix"

which represent graphically activities on one axis of a grid, and affected environmental systems or components of systems on the other axis. The technique allows an estimate to be made of negative or positive impacts of any kind on any kind of system, whether biophysical, ecological or cultural. The environmental impact assessment may be quantified by assigning a range of values to the magnitude and importance of the effect of an activity on existing characteristics and conditions of the environment. In the present use of the matrix, values were assigned subjectively on estimates by the writer of the magnitude and importance of effects of activities directly related to proposed construction of the Rivière des Rochers weir and the removal of the Chenal des Quatre Fourches dam, the latter which had been built as a temporary expedient, to flood wetlands in Wood Buffalo National Park, until a permanent remedy could be found to restore the Delta as a whole.

Examination of the effects of the proposed activities culminating in restoration of Delta water levels leads to the conclusion that virtually all environmental impacts are positive. It is not necessary therefore to consider in any detail the weight of minor disbenefits, but rather to estimate the magnitude and importance of benefits which will accrue if Delta water levels are restored. Considerable confidence can then be held in the predictability of extent of resource use on the Delta which can take place in the future, plus the degree to which such resource use may contribute to the well-being of the Delta residents.

3. THE DELTA RESOURCES

The resources of the Peace-Athabasca Delta are many and varied. It is difficult for one who does not live in the area to estimate their values to those who reside there. The life style of Delta residents is uniquely adapted to, and dependent on, their natural surroundings. The following summary will only provide a catalogue of the major resources available for use to the people of the area. For convenience an arbitrary division has been made in resources of the area, by dividing them into biological and non-biological categories. Biological resources of importance to Delta residents include mammals, birds, fishes and some species

of vegetation; non-biological resources include minerals, the potential tourist industry and employment opportunities in the transportation industry, Federal or Provincial Government, or supportive service industries. An attempt will be made to identify the present kind and level of resource development and its present actual and future possible relationship to the community of Fort Chipewyan.

3.1 Biological Resources

The Peace-Athabasca Delta is rich in biological resources. Marshlands of the Delta consist of warm, shallow water-covered areas, where primary productivity is high. With a high level of insolation energy and nutrient enrichment provided each spring from the silt carried by the inflowing river waters, conditions are ideal for a variety of plant growth. It is the rich plant growth which sustains several species of birds and mammals, and in some cases provides spawning or rearing habitat for fish.

The large sedge and grass meadows are typical of marshland plant associations, and the several thousand bison of the Delta depend on these meadows for feed all year. Farther back from the open water-covered areas, willows and other deciduous species provide moose habitat on which depend the several hundred moose of the Delta proper. Bison are relatively unused by Delta residents. Hunting within Wood Buffalo National Park is not allowed, and availability of bison outside the Park is limited and infrequent. Moose are heavily utilized, to the point where the Delta population of moose is below carrying capacity. Black bears are taken when available, but are not as common on the Delta as on the Canadian Shield woodland habitat to the northeast of Fort Chipewyan. No other large mammals are found in sufficient numbers on the Delta to be of significant value to local residents.

The Delta marshes and mud flats provide an important piece of habitat for waterfowl. As a staging and resting area for waterfowl, both on northward and southward migration, and as a feeding, moulting and breeding area, the Delta may harbor well over 1,000,000 ducks, geese and swans in a single season. The unique character of the Delta marshlands makes it a key element of great importance to waterfowl of four continental flyways.

Little information is yet available concerning the relationship of Delta waters to fish production in the area. It is known that walleye from Lake Athabasca spawn in Richardson Lake, which may be the single most important walleye spawning area for Lake Athabasca. Lake Claire and Mamawi Lake may also provide some spawning habitat for walleye, but little is known yet of the importance of those waters to Lake Athabasca walleye.

Recent studies confirm, early but scant information on goldeyes, which live in the Peace River and move upstream into Lake Claire to spawn. Larval goldeye spend some time in Lake Claire before moving back into the Peace River to complete their life history.

Northern pike are common throughout the Delta area, and very large fish (in excess of 20 pounds) are not rare in some of the Delta river channels. Spawning requirements for pike are such that it is likely that the margins of the Delta lakes where flooded grassy areas are available, may be important for successful reproduction.

Whitefish are common in the shallow waters of the west end of Lake Athabasca, as are tullibee. Lake trout are found in the deeper, cooler waters of the main body of Lake Athabasca. None of the three species mentioned above inhabit the Delta proper, but all rely for successful spawning on suitable beach substrates. Low water in Lake Athabasca could have serious consequences for maintenance of whitefish, tullibee and lake trout.

The single most important species of animal on the Delta is the muskrat. It has provided the basis for the fur trapping industry at Fort Chipewyan for well over 100 years. Water levels on the Delta marshes are critical for the production of muskrats. Not only do suitable water levels result in the production of plants which are eaten by muskrats, but also sufficient open water under the ice is critical to mobility of the animals in reaching their food supply. Furs in 1973 reached very high prices with muskrats averaging over $3.00. If 100,000 muskrats had been trapped in the winter of 1972-73 (as some Delta residents state has happened in the past) over $300,000. could have flowed into the community of Fort Chipewyan from this source alone.

Timber harvesting in the area has in the past provided employment for a limited number of residents of Fort Chipewyan. Because logging activities are not centered near the town of Fort Chipewyan, interest is not high in the timber industry. A potential source of revenue for the local residents exists in the so-called "diamond willow" of the area, which has extensive stands of this species. The wood is peeled of its bark and used for the manufacture of a variety of objects, including furniture such as chairs, lamp stands, and similar objects. A steady supply of driftwood is available along the numerous river channels, where trees often fall into the water from eroded banks. The potential for sale of driftwood for ornamental objects is not known, but the supply is virtually unlimited.

3.2 Non-biological Resources

Traditionally, residents of the Delta area have not been heavily involved in use of non-biological resources. Nor have they been able to take advantage of the resources of transportation employment or employment with Government to any significant degree. Most Delta residents have little training which might suit them for employment in technical or skilled occupations, and also, employment might result in having to relocate outside the community, which in the past has discouraged many older residents of Fort Chipewyan from involvement in occupations other than trapping, fishing and hunting.

Through much of northern Canada, minerals provide a base for resource development. While mining for metallic minerals has been the major reason for development of numerous communities elsewhere, no metallic ore deposits of significance apparently exist near the Delta. As a result, little direct effect has been felt in the community. In addition, mineral exploration to date has not revealed petroleum or other fossil fuel resources in close proximity to the Delta area or the community of Fort Chipewyan.

Potential for employment in Government service rests largely on decisions which may be made by Governments as to the desired level of activity in the Delta region. During the research program by the Peace-

Athabasca Delta Project Group, local residents were employed whenever possible. It is not known yet what Government activities may continue to offer employment, but jobs are directly related at present to expenditure levels of Federal and Provincial agencies, supplemented by modest and infrequent research efforts by research branches of Government or by University research programs.

Perhaps largely as a result of location, Fort Chipewyan has received little benefit from oil or gas pipeline environmental impact studies. Largely because of location also, Alberta oil sand activities have had little effect on the local community, although employment has been possible for those who choose to move to Fort McMurray or Fort McKay, to work in oil sands development projects.

The general picture at present is not encouraging for benefits to Fort Chipewyan from involvement with non-biological resources. Jobs are not plentiful in the Delta area, and are generally available only for short time periods for unskilled persons. For those with more advanced educations and skills, better opportunities appear to exist in other areas.

4. THE PEOPLE OF THE DELTA

The history of occupation in the Peace-Athabasca Delta area (2) and the present social structure of Fort Chipewyan (10) have been examined and reported on previously, in the Proceedings of the Symposium held on the Delta problem in 1971 (5). A brief recapitulation is provided here, in order to orient the present and possible future resource use discussion to follow in Sections 5 and 6.

4.1 Crees

The present social organization of the community of Fort Chipewyan is strongly influenced by Cree traditions. Not only was social organization practiced much earlier by Crees than any other woodland Indians of Central Canada, but also they rapidly adapted to the first European intrusions, as well as taking unto themselves the skills and materials of the white traders

and explorers, without giving up their own language and traditions. Perhaps because of their numerical strength (which comprises 47% of the population of Fort Chipewyan) as well as their social influence by tradition, the Crees are the dominant segment of the community at present.

4.2 Chipewyans

Of the population of Fort Chipewyan, 15% are native Chipewyan people, and other than the few whites, this represents the smallest identifiable segment of the community. In the past, the Mackenzie Indians, including Chipewyans, accepted European culture more rapidly than Crees, and came close to extinction as a cultural group. As a result, the Chipewyans of the Delta have not maintained as strong an identity as have the Crees. Nevertheless, the Chipewyan Indian Band numbers more than 230 persons, and with the Crees have a place of importance in any considerations of resource development or environmental management.

4.3 Metis

The Metis of Northern Canada exist in every remote community, and Fort Chipewyan is no exception. The Metis of the Delta area have intermarried with both Chipewyans and Crees, but under the law, are not accorded the status given to native Indians under Federal legislation. As a group in the social structure of Fort Chipewyan, the 450 Metis are a highly significant entity, comprising the second largest group (33%) in the community. The Metis members of the community provide significant inputs to leadership and organization. Perhaps because they are not given a status as native people, and have no reserves, their mobility is generally greater, and their attitudes to changing conditions are relatively flexible.

4.4 Others

In addition to the Cree, Chipewyans and Metis of the Delta area, there are in Fort Chipewyan or nearby, a few more than 100 white residents. Some are public servants, employed by various Federal or Provincial agencies, transportation employees, local businessmen and a few trappers. Some of the

white residents of Fort Chipewyan have lived in or near the community for many years, and have assumed a place in the community life of the area. Others have been more transient, as business interests or employment opportunities dictated. The white segment of the community of Fort Chipewyan is numerically weak, but influential in local affairs.

The Indian and Metis people of Fort Chipewyan will increase by about 35% in the next eight years, if present trends continue; the non-native population is unlikely to change much, unless new events of significant importance alter the basic community support systems. The future therefore should be judged in relation to the needs of the majority of Delta people, plus the requirement for increased employment opportunities, as the population grows.

5. HISTORICAL AND PRESENT RESOURCE USE IN THE DELTA AREA

5.1 Dependence on Biological Resources

It has been substantially documented (2) that the community of Fort Chipewyan has been the focus of resource activity for a very long time in the southern end of the Mackenzie River basin. As well, it has been reported (11) that a heavy dependence has always existed on biological resources of the area by Delta residents. Thus the following analysis assumes that the relationship between human ecology and biological resources in the Delta is fundamental to any consideration of historical and present resource use in the area.

5.1.1 The Past 200 Years

For about two centuries the people of the Delta area have been steeped in the traditions of their several cultures, heavily influenced by European technology. Although large changes have occurred, and the pace of change today may be accelerating, it would be a mistake to assume that patterns of living have shifted in any fundamental way. Over the past 200 years, ungulates and fish have sustained life by providing food, and some degree of purchasing power has always existed with the yearly harvest of furbearers.

The environment in the Delta has always been harsh for its residents. Yet, without much direct assistance until comparatively recent times, the number of people in the Delta has slowly increased, and consolidation of residential patterns has resulted in the permanent community of Fort Chipewyan. The only resources of any consequence which could have resulted in survival of human settlement are those which in themselves have evolved in response to deltaic conditions. It has been suggested that the history of resource use in the Delta has shown a steady progression away from fur trapping, fishing and hunting. No published evidence exists to support such a contention, nor does contact with local residents suggest that the patterns of resource use of the past two centuries have passed into oblivion.

5.1.2 The Present Situation

While it has been strongly suggested in the preceding section that dependence on biological resources of the Delta still strongly influences life patterns of local residents, the vicissitudes of climate have in the past made it difficult to depend on such resources with great certainty. Years of drought sometimes resulted in virtual elimination of muskrats for a few years. Lately, fluctuations in demand for furs caused prices of muskrat skins to fluctuate six-fold. Several years ago muskrat skins sold for as little as fifty cents each. At the 1973 spring fur auction in Edmonton, they would have brought $3.00 each. Supply of fish, and ungulates has been somewhat more predictable, since these animals occupy habitat not as drastically affected by fluctuating water levels in the marshlands, which make muskrat survival dubious in low water years. Commercial fishing results in variable returns to residents of Fort Chipewyan. Distance from markets, plus the expense of air freight charges for highly perishable fresh fish impose severe limitations on successful maintenance of an economically viable operation.

As far as can be determined, use of fish and furbearers has not had the benefit of long-range planning by Government either at the Federal or Provincial level, although assistance to fishermen has been supplied by Federal programs, through provision of fishing boats and gear. Transportation

companies have not made much effort to encourage shipment of fish at backhaul rates whether by air or barge. Transfer of all operations of the Freshwater Fish Marketing Corporation to Saskatchewan has posed an added difficulty for fishermen to ship their fish.

In summary, biological resources (fish, furbearers, birds, ungulates) at present provide a maintenance living for a number of Delta residents. It is difficult to project increases in exploitation of these resources, under present conditions.

6. PROSPECTS FOR THE FUTURE

The foregoing discussion has attempted to set the stage for evaluation of future prospects. In Section 2.3.1 the three alternatives for water regimes on the Delta were outlined, and the assumption made that the only reasonable course of action involved construction of a submerged weir on the Rivière des Rochers, following which the Delta would be returned to a condition approximating that which occurred before the Peace River was impounded in British Columbia. The following discussion related to the effects of such an action on the people of Fort Chipewyan.

6.1 Delta Productivity

Intensive studies of the hydrology and ecology of the Peace-Athabasca Delta in the past two years strongly suggest that productivity of the area will be little different after the construction of a regulating weir on the Rivière des Rochers than it was before the Peace River was brought under regulation. Implications for the future are therefore entirely dependent on the predictability of water levels on the Delta and subsequent productivity of the Delta area. According to mathematical models which can use hydrologic or ecological data, predictability is good. The analysis which follows therefore assumes that sufficient knowledge exists to state with reasonable confidence how regulation of Lake Athabasca and Delta water levels will provide Delta residents the opportunity to develop and use the resources of the area.

One other point should be made clear - it would be naive to suggest that the ecological situation on the Delta is simple; obviously it is not. However, the complex interrelationships of the water regime and the plant and animal communities should not be viewed as in any way limiting the proposal to return the water regime to its pre-impoundment state. Indeed, the reverse is true, and the highly complex interrelationships resulting from fluctuating water levels of great variability provide in turn the biological variability which makes possible a viable and productive ecosystem.

6.2 Resource Use in the Alberta Portion of the Delta

Consistent with regulation of Lake Athabasca and the Delta water levels to achieve and maintain a high level of productivity, at least five major resource potentials can be identified. Development potential is most readily apparent in (1) Fur trapping (2) Commercial fishing (3) Tourism (4) Sport fishing and (5) Sport hunting. These resource areas have been suggested as having obvious potential for development; as well, they are all highly labor intensive, which should be advantageous in a community where employment opportunities are restricted.

6.2.1 Fur Trapping

At least one study (10) has indicated that substantial income could be generated from the fur resources of the Peace-Athabasca Delta. It was also mentioned earlier in this discussion that a potential of about $300,000 might have been realized on the Delta in 1973, from muskrat alone, had there been animals to trap. Some local trappers and their families have in the past trapped up to 10,000 muskrat in a single season (12). At 1973 fur auction prices, such a harvest could have realized over $30,000 cash income. Fur prices however, fluctuate drastically, and it is difficult to predict the future economics of the fur industry. Nevertheless, it would be a serious error to make the assumption that fur is not important to Delta residents. In any assessment of the impact of the proposal to regulate the Rivière des Rochers and restore water levels on the Delta marshlands, fur (especially muskrat) must be recognized as a most important resource.

6.2.2 Commercial Fisheries

Assuming that fish productivity remains high, potential for further development of commercial fisheries also is high. One study (13) has estimated that a potential exists for harvest of about 5,000,000 pounds per year of commercially saleable fish. Five fish species are available for harvest - walleye, pike, whitefish, suckers and ling. As well, some potential is available for harvest and local processing of goldeye. If the estimate of 5,000,000 pounds per year is at all close, and at a conservative net price of 10 cents per pound, the cash flow into the community of Fort Chipewyan could approximate $500,000 per year, or slightly over $300 per capita. Aside from employment directly in the net fishery for the various species, processing of fish could also provide a number of shore-based jobs in dressing, filleting and repacking of fish for shipment to southern markets.

The future of commercial fishing at Fort Chipewyan is dependent not only on the supply of fish. Markets are far to the south, and the flow of fish must be steady, of high quality, and at a cost which can provide a reasonable income to the fishermen and shore-based workers. No long-range plans exist as yet for adequate and reasonably priced air transport of fish products from Fort Chipewyan, and the nearest fish plant of the Freshwater Fish Marketing Corporation is in Saskatchewan. In 1970, a newly formed fishermen's co-operative commenced operation at Fort Chipewyan, with limited success. Stability in the fishery, therefore, will require solid planning, in relation to water levels and also in relation to sustained maximum yields and sales of fish and fish products.

6.2.3 Tourism

Little concrete information presently is available as to the development of a tourist industry for the Peace-Athabasca Delta, although the data which do exist indicate that a major tourism potential might be developed. However, at present, there is very little tourist use of the area. Although tourism itself cannot be classed as a biological resource, obviously the animals and plants of the Delta would relate strongly to tourist appeal. Marshland areas generally have a rich complement of floristic and faunistic

species, and the Peace-Athabasca Delta is no exception. No detailed studies exist of tourist potential, but in Europe and the U.S., areas of lesser potential than the Delta long have been recognized as visitation centers for naturalists, bird watchers and the like. Recently, frequency of enquiries from Europe has increased, and the opportunity appears to exist for Government and the air transportation companies to explore the possibilities of a sharply expanded tourist industry. There is little doubt that the construction of a weir on the Rivière des Rochers would have the positive impact of providing conditions which could maximize tourist use of the Delta. As in the case of commercial fishing, tourism is heavily labor intense.

6.2.4 Sport Fishing

The Peace-Athabasca Delta provided an abundance of opportunities to fish for trophy pike prior to 1968, before water levels were altered by regulation of the Peace River. In addition, walleye sport fishing was excellent. It can be assumed that fishing for pike and walleye will be as good in future as in the past, if water levels are restored by construction of the regulatory weir on the Rivière des Rochers. Intensity of sport fishing in the Delta channels has never been strong, but quantitative information is not available. All that can be said at present is that the potential is high, and that the same fishermen who fish commercially could also use their boats to cater to sport fishermen.

6.2.5 Sport Hunting

Sport hunting at present is not practiced to any significant degree in or near the Delta marshes. The few outsiders who have hunted there have, however, indicated that superlative waterfowl hunting opportunities exist on some portions of the Delta. Knowledge of land forms and future water levels is essential before any predictions could be made of the long-term future of sport hunting for waterfowl, and it is assumed that this knowledge is now available from the recent studies by the Peace-Athabasca Delta Project

Group. Internal regulation of water in the Delta could effect improvement in waterfowl hunting for sourthern Alberta (and the U.S.). However, such improvement would not benefit Fort Chipewyan unless the management scheme were also designed to take full advantage of hunting opportunities in the Delta area and to employ native people in transportation and guiding services. As with sport fishing, the dollar potential is unknown, but probably high. It should be emphasized that any development of sport hunting opportunities would be restricted to areas outside Wood Buffalo National Park.

6.2.6 Other Resource Use by Delta Residents

Resource use opportunities in the Alberta portion of the Peace-Athabasca Delta appear to be severely limited in the non-biological resource field. Apparently there are few economically recoverable mineral resources, although some excellent colored granites are exposed surficially. As indicated earlier, mineral exploration has not revealed petroleum or other fossil fuel resources. Development of the Alberta oil sands presently centers on Fort McMurray, 150 miles to the south. Insofar as oil sand reserves are presently known (14), further oil sands development will not directly involve the Delta residents or the community of Fort Chipewyan, except as a source of employment opportunities for those who might wish to relocate. As a consequence, it is difficult to see how mineral resource development in general (barring new discoveries in the area) and oil sands development in particular, can directly benefit those who wish to remain in the community of Fort Chipewyan or the surrounding Delta area.

6.3 Resource Use in Wood Buffalo National Park

The basic assumption is made that future physical resource development will not take place in Wood Buffalo National Park, in line with publicly stated National Parks policy for the rest of Canada (15). If such an assumption is valid, use of resources in Wood Buffalo National Park will be largely non-consumptive. It is recognized that fur trapping at present is carried out in the Park, and that a potential exists for a goldeye fishery in or adjacent to the Park. The future of such activities is by no means clear, because firm policy has not been publicly stated by the Federal Government.

Almost no use of Park resources is made at present by Canadian or non-Canadian bird watchers, tourists, naturalists, wildlife photographers, or those with similar inclinations. The available floral and faunal resources of Wood Buffalo National Park are probably less known to the Canadian public than any other National Park established for the same length of time. Yet the rich diversity of plant and animal life in the Park, as well as the rest of the Delta area, provides an immense potential, which could allow the Delta portion of Wood Buffalo National Park to become one of the best known such areas in the world. The Delta portion of the Park could achieve its true function as one of Canada's most valuable National Parks, as well as recognition as a unique natural area and one of the great freshwater deltas of the world.

Local residents, on foot in winter months or in suitable boats or canoes in summer, could provide the means of creating an awareness of resources in Wood Buffalo National Park which have thus far gone largely unnoticed. With adequate integration of resource potentials in the Park with the capabilities of local residents, it is obvious that the extensive marshlands within the southeastern (Delta) portion of the Park are highly useable, and have a high potential for generating employment opportunities in tourist services.

Regulation of water levels by the Rivière des Rochers weir appears to provide the only reasonable alternative for making non-consumptive resource development opportunities in Wood Buffalo National Park available to Delta residents. Thus, the potential impact of the weir has very wide and important consequences for Canada's largest National Park and 1500 Canadian citizens in the immediate vicinity.

6.4 Resource Use Outside the Delta Proper

Examination of resource use potential, as well as future prospects, has been confined so far to the Delta itself, either in Alberta or in Wood Buffalo National Park. With respect to tourism and sport fishing particularly, there are two areas of outstanding beauty and high potential near

the Delta but not part of it, i.e., the Canadian Shield in Alberta, north and east of Fort Chipewyan, and the Athabasca Sand Dunes, south and east along the south shore of Lake Athabasca.

6.4.1 Canadian Shield in Alberta

The Canadian Shield in Alberta is one of the most attractive parts of the Province. Covering about 3000 square miles, it contains several hundred lakes with excellent fish populations, many hundreds of miles of clean sand beaches and topography and vegetation in a state of pristine beauty. Fort Chipewyan would be a logical center for tourist operations in the Shield area, and its residents would be the logical choice to provide services to visitors.

6.4.2 Athabasca Lake Sand Dunes

During the post-glacial period, wind erosion has resulted in deposition of Athabasca sandstone in large dunes east of the Athabasca River, south of Lake Athabasca. The dunes are of spectacular beauty, and have on them endemic species of plants and animals. With care, the dune areas could be preserved for the foreseeable future as glacial relics of great interest to naturalists, scientists and other visitors to the region. As in the case of the Canadian Shield north of Fort Chipewyan, the dunes could become a visitation area centered on Fort Chipewyan, and with transportation and guiding services provided by local residents.

6.5 Community Development

Community development anywhere ultimately depends on the local residents, and perhaps this fact is more important in isolated communities than elsewhere. Fort Chipewyan in a sense is suspended between life in the past and dimly perceived prospects for the future. Residents of Fort Chipewyan have always existed under hostile environmental conditions. As well, economic viability was never realized by the community.

Transition from the past has been slow, but by about 1965 the people of the area had begun to perceive that a relatively productive life

could lie ahead for themselves and their children, with effort on their part, and with help from Federal and Provincial Government agencies. Closure of the dam at Portage Mountain on the Peace River in British Columbia, with resulting extensive environmental consequences, initially caused a withdrawal from active planning for the future. Lately however (16), community interest has increased sharply, and expectations appear to be high in local residents that future planning can be based on the report (7) recently published by the Peace-Athabasca Delta Project Group.

6.5.1 Technical Training and Development

Post-grade school education for Fort Chipewyan residents is not available in the community. Employment opportunities are so restricted that no impetus is provided, or demand created for employment of those above the level of unskilled physical labor. Increasing numbers of young people (12) are expressing a preference for relocation elsewhere, where employment opportunities are more numerous and more variable.

Future training and education at the level of technical institute or equivalent will be necessary to fit young Delta residents for the task of optimizing resource use in the area. Obviously, unless there are opportunities for resource use, such training would be wasted. For the future, technical training and education must be considered in relation to the planned opportunities for local involvement in use of the resources of the area, if the water level management proposals are implemented.

6.5.2 Government Services and Employment

Opportunities for further community development are closely related to the level of activity generated by Government and allied services. At present, employment of local residents in technical or supervisory positions is virtually non-existent, largely because of lack of training and education of local people past the grade school level. Depending on Federal Government policies for Wood Buffalo National Park or Alberta Government policies for the Delta area under Alberta jurisdiction, job opportunities could be

Alberta thus has the major responsibility for the future of the Delta, in relation to the people who reside there.

All the available evidence concerning human habitation of the Delta strongly points to maximizing social and economic benefits through increased use of Delta resources by local residents. There appears to be available, a relatively straightforward engineering solution to the water level problem. In terms of social and economic benefits if successful remedial measures are undertaken and in terms of future social and economic costs if they are not, the capital costs for restoration of water levels in the Delta are relatively small. The impacts of the proposal for construction of the Rivière des Rochers weir are positive.

The assumed positive benefits or the possible disbenefits of remedial action on the Peace-Athabasca Delta relate most strongly to the Government of Alberta. It is within Alberta that the present problems exist; it is within Alberta that the people of the Delta live. The flow of commerce into and from the Delta connects most closely with the Alberta scene. Government and other services center at Fort Chipewyan, a community for which the Government of Alberta has ultimate responsibility. Notwithstanding that the Government of Canada and the Government of Saskatchewan have special and important interests in the region, it is the Government of Alberta which is required to assume the most significant role in the future of the Delta and its people.

It is the conclusion of this report that the initiatives for future management direction of the Peace-Athabasca Delta should relate most strongly to the Government of Alberta, with close liaison with the Government of Canada and the Government of Saskatchewan. It is also the conclusion of this report that with imaginative and positive management direction, as well as with involvement, determination and effort by the local people, there is a good probability for future economic stability and human dignity for the 1500 Canadian citizens who choose to live at Fort Chipewyan and in the surrounding area. Finally, it is the conclusion of this report that implementation of the proposal to construct a weir on the Rivière des Rochers should not be delayed beyond the winter of 1973.

REFERENCES

1. Peace-Athabasca Delta Committee, Death of a Delta, 1970. 19 pp., mimeo., Edmonton, Alberta, Unpubl.

2. Wuetherick, Robert G., 1972. A History of Fort Chipewyan. Unpubl. M.S., Peace-Athabasca Delta Project. Baker Center Building, Edmonton, Alberta.

3. Bennett, R.M., 1971. Lake Athabasca Water Levels, 1930-1970. *in* Proceedings of the Peace-Athabasca Delta Symposium, University of Alberta, Edmonton, Alberta.

4. Peace-Athabasca Delta Project Group, 1972. The Peace-Athabasca Delta, A Canadian Resource. Summary Report, 144 pp., illustrated.

5. Proceedings of the Peace-Athabasca Delta Symposium, 1971. University of Alberta, Edmonton, Alberta.

6. Peace-Athabasca Delta Project, 1971. Report of the Director. 36 pp., litho., illustrated. Peace-Athabasca Delta Project, Bulletin Commercial Printers, Edmonton, Alberta.

7. Peace-Athabasca Delta Project, 1973. Final Report of the Technical Committee. Peace-Athabasca Delta Project, Edmonton, Alberta.

8. Fuller, W.A. and G.H. LaRoi, 1971. Historical Review of Biological Resources of the Peace-Athabasca Delta. *in* Proceedings of the Peace-Athabasca Delta Symposium, University of Alberta, Edmonton, Alberta.

9. Dirschl, J.H., 1971. Ecological Effects of Recent Low Water Levels in the Peace-Athabasca Delta. *in* Proceedings of the Peace-Athabasca Delta Symposium, University of Alberta, Edmonton, Alberta.

10. Dixon, P.G., 1971. Local Society and Economy of Fort Chipewyan, Alberta. *in* Proceedings of the Peace-Athabasca Delta Symposium, University of Alberta, Edmonton, Alberta.

11. Smith, S.B., 1973. Biological Resources in Relation to Human Ecology at Fort Chipewyan, Alberta. *in* Proceedings of the Symposium on Lakes of Western Canada, University of Alberta, Edmonton, Alberta.

12. Ladouceur, Frank, 1973. Personal Communication.

13. MacDonald, Dennis G., 1965. Lake Athabasca in Alberta. Unpubl. M.S., Fish and Wildlife Division, Alberta Department of Lands and Forests, Edmonton, Alberta.

14. Oil and Gas Conservation Board, 1971. Map of Alberta, showing Designated Oil and Gas Fields, Main Pipe Lines, Refineries, and Gas Plants. Revised to April, 1971. Calgary, Alberta.

15. National Parks Act, Canada. Queen's Printer, Ottawa, Ontario

II PROPOSED ACTIONS WHICH MAY CAUSE ENVIRONMENTAL IMPACT

INSTRUCTIONS

1- Identify all actions (located across the top of the matrix) that are part of the proposed project.

2- Under each of the proposed actions, place a slash at the intersection with each item on the side of the matrix if an impact is possible.

3- Having completed the matrix, in the upper left-hand corner of each box with a slash, place a number from 1 to 9 which indicates the MAGNITUDE of the possible impact; 9 represents the greatest magnitude of impact and 1, the least, (no zeroes). Before each number place + if the impact would be beneficial. In the lower right-hand corner of the box place a number from 1 to 9 which indicates the IMPORTANCE of the possible impact (e. g. regional vs. local); 9 represents the greatest importance and 1, the least (no zeroes).

4- The text which accompanies the matrix should be a discussion of the significant impacts, those columns and rows with large numbers of boxes marked and individual boxes with the larger numbers.

SAMPLE MATRIX

	a	b	c	d	e
a		2/1			8/5
b		7/2	8/8	3/1	9/7

			A. DAM REMOVAL AND WEIR CONSTRUCTION	B. MODIFICATION OF REGIME	COMPUTATIONS
			a. Temporary construction camps b. Quatre Fourches dam removal c. Excavation rehabilitation d. Surface excavation e. Dams and impoundments f. Blasting and drilling g. Cut and fill	a. Modification of habitat b. Alteration of ground cover c. Alteration of ground water hydrology d. Alteration of drainage and channel capacity e. River control and flow modification	
I EXISTING CHARACTERISTICS AND CONDITIONS OF THE ENVIRONMENT	A. PHYSICAL AND CHEMICAL CHARACTERISTICS	1. EARTH	a. Mineral resources		
			b. Construction material		
			c. Soils		
			d. Land form		
			e. Unique physical features		
		2. WATER	a. Surface		
			b. Underground		
			c. Quality		
			d. Temperature		
			e. Recharge		
			f. Snow, ice and permafrost		
		3. PROCESSES	a. Floods		
			b. Erosion		
			c. Deposition and nutrient replacement		
			d. Solution		
			e. Sorption (ion exchange, complexing)		
			f. Stability (slides, slumps)		
	B. BIOLOGICAL CONDITIONS	1. FLORA	a. Trees		
			b. Shrubs		
			c. Grass		
			d. Microflora		
			e. Aquatic plants		
		2. FAUNA	a. Birds		
			b. Land animals including reptiles		
			c. Fish and shellfish		
			d. Benthic organisms		
			e. Insects		
			f. Microfauna		
	C. CULTURAL FACTORS	1. LAND USE	a. Wilderness and open spaces		
			b. Wetlands		
			c. Grazing		
			d. Residential		
			e. Industrial		
			f. Mining and quarrying		
		2. RECREATION	a. Hunting		
			b. Fishing		
			c. Boating		
			d. Bird watching		
		3. AESTHETICS AND HUMAN INTEREST	a. Scenic views and vistas		
			b. Wilderness qualities		
			c. Unique physical features		
			d. Parks and reserves		
			e. Rare and unique species or ecosystems		
		4. CULTURAL STATUS	a. Cultural patterns (life style)		
			b. Employment		
			c. Population density		
		5. MAN-MADE FACILITIES AND ACTIVITIES	a. Structures (docks)		
			b. Transportation network (movement, acces)		
			c. Channel dredging		
	D. ECOLOGICAL RELATIONSHIPS SUCH AS		a. Salinization of water resources		
			b. Eutrophication		
			c. Food chains		
			d. Salinization of surficial material		
			e. Brush encroachment		
			f. Other		
COMPUTATIONS			1.2/.11 2.1/1.8 1.3/1.1 1.3/1.2 1.0/1.1 1.1/1.1 1.1/1.0	5.0/4.4 3.6/3.2 2.8/3.0 2.0/1.6 2.1/2.1	

NOTE:
(1) DESIGNATION 1/1 INDICATES MINIMAL EFFECTS OR NO EVIDENCE FOR EFFECTS, EITHER POSITIVE OR NEGATIVE

INFORMATION MATRIX FOR ENVIRONMENTAL IMPACT ASSESSMENT

DATE DUE
DATE DE RETOUR

NOV 22 1982

LOWE-MARTIN No. 1137